NASA Composites Technologies Available to Industry

Bob Lessels/LA02
205–544–6539
E-mail: bob.lessels@msfc.nasa.gov

Work at the Marshall Center to develop composite materials and technologies for use in the space Agency's Space Shuttle follow-on vehicle program should pay a number of dividends for American industries.

According to John Vickers, an engineer in the Materials and Processes Laboratory's Nonmetallic Materials Processes Branch, manmade composite materials technologies can offer significant advantages over metals when applied to structural programs and to programs where thermal problems are anticipated. Because composite materials are light and strong, they have already found their way into sports equipment. Tennis racquets, fishing rods, skis, boat hulls and golf club shafts are but a few examples.

"Various composite materials have different properties which can be tailored to suit the needs of the user," Vickers explained. "For structural applications where high strength and stiffness are most desirable, carbon or graphite fibers are combined with resins to achieve the desired results with the least weight. This, however, is the most costly approach. In situations where damage resistance is paramount and weight is not a major concern, Kevlar may be substituted for carbon or graphite. The most economical material is fiberglass, but it normally has the lowest strength-to-weight ratio. Being silica-based, fiberglass is very good for work involving thermal extremes as it has a low coefficient of expansion. The resins may be preimpregnated into the strips of fibers or the design engineer may elect to apply the epoxy or polyester resin later or during the manufacturing process."

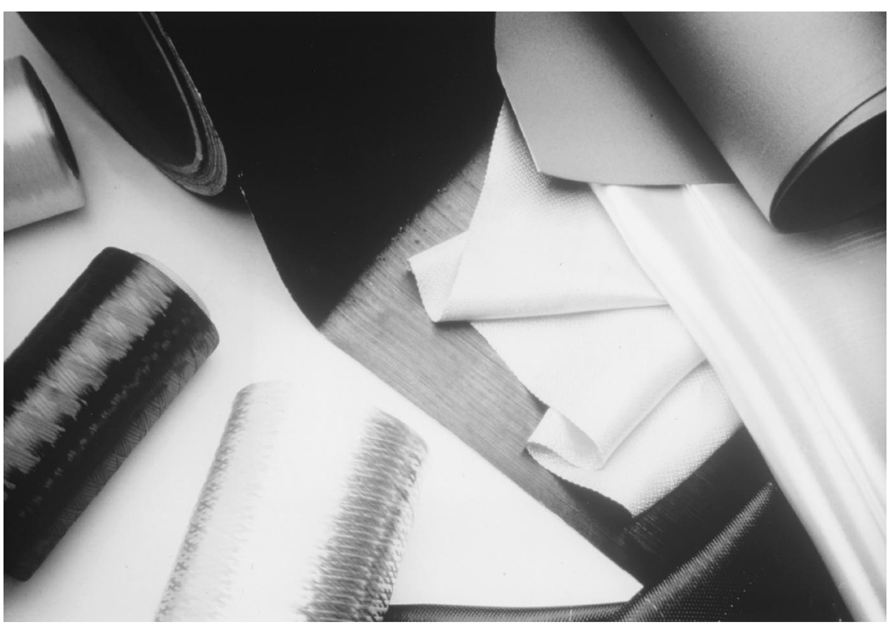

FIGURE 202.—Various composite materials have different properties that can be tailored to suit the user.

Regardless of the type of fiber selected, all are combined with a polymer resin such as epoxy or polyester which holds the fibers in place. A number of advanced resins have been developed for use in high-heat/cryogenic applications. Most epoxy and polyesters are thermoset resins which require elevated temperatures to completely cure.

According to Vickers, "The Reusable Launch Vehicle (RLV) Program is receiving a lot of attention from materials engineers and scientists as NASA seeks a follow-on craft for the present Space Shuttle. We've already used composites to fabricate cryogenic fuel pressure vessels for the RLV. These technologies may soon show up in the family automobile as attention is given to using liquefied natural gas as a low-emission fuel. Being extremely cold in its liquid state, liquefied natural gas will require an insulated, pressurized fuel tank. Insulation will probably be similar to the spray-on foam insulation now in use on the Space Shuttles' external fuel tank. We've already done some work, through the Marshall Center's Technology Transfer Office, with Thiokol Corp. in developing a compressed natural gas fuel tank for use on a minivan. We're also looking at composites for use in the Chrysler Corporation's proposed Patriot II formula one racing car, which also is expected to use liquefied natural gas as a fuel contained in an insulated, pressurized tank made of composite materials."

Marshall's work in developing composites technologies involves employing a number of specialized machines.

The filament winding machine lays down resin/fiber composite "ribbons" which are built up layer by layer until the desired thickness and degree of strength is achieved. Computer directed, the device is used to make pressure vessels and similar items which have symmetrical shapes. "As with many metal-working machine tools," Vickers said, "the filament winding machine was designed to do one job but has been adapted to perform others."

The pultrusion machine is similar to an extrusion machine. “Unlike metals, resin fibers can’t be pushed through a machine. It’s like trying to push a rope. The strand of epoxy-impregnated resin must be pulled through the die to shape it. Pultrusion technologies lend themselves to making long, continuous geometry shapes. This is a continuously operating machine in that, once set up, can be run for long periods. Pultrusion techniques have a number of structural applications,” Vickers explained. “All types of fiber—carbon/graphite, Kevlar, or fiberglass—can be used depending on the desired physical properties of the finished composite item.”

The laboratory’s tape laying machine enables engineers such as Vickers to fabricate very large, somewhat contoured structures with asymmetrical geometries.

The lab’s Viper CNC Fiber Placement System is the first of its kind. Built by Cincinnati Milacron Inc., the machine was initially used to make inlet ducts for experimental jet fighter prototypes. “Even now, there are only 10 or so of these systems in the entire world,” Vickers said. “Marshall has been a leader in testing its potential applications in manufacturing composite parts with extremely complex geometries. The resin/fiber tools can be applied in patterns which can be narrowed or expanded to maintain a constant cross-sectional thickness. This is a very sophisticated, computer-controlled system whose uses are only beginning to be discovered and exploited. Possibly the most unusual application has been to fabricate from epoxy resin and graphite a human-powered submarine for a national student engineering competition in which the University of Alabama in Huntsville is an annual participant.

The lab’s tape wrapping machine was designed to build solid rocket motor nozzles, simulating those used for the solid rocket motors on the Space Shuttle. It has been adapted to make nozzles for engines which burn hybrid (solid fuel/liquid oxidizer) propellants and liquid fuels. Using carbon composites for the nozzles has a number of benefits. As the motor operates, gases from the composite resin evolve from the inside of the nozzle, acting as a passive cooling system. A carbon char layer builds up on the inside of the nozzle which also protects the nozzle from the heat of the motor’s flame. In fabricating some nozzles, engineers replace the carbon with silica, Vickers explained, especially when the nozzle will be operating in a high-oxygen environment.

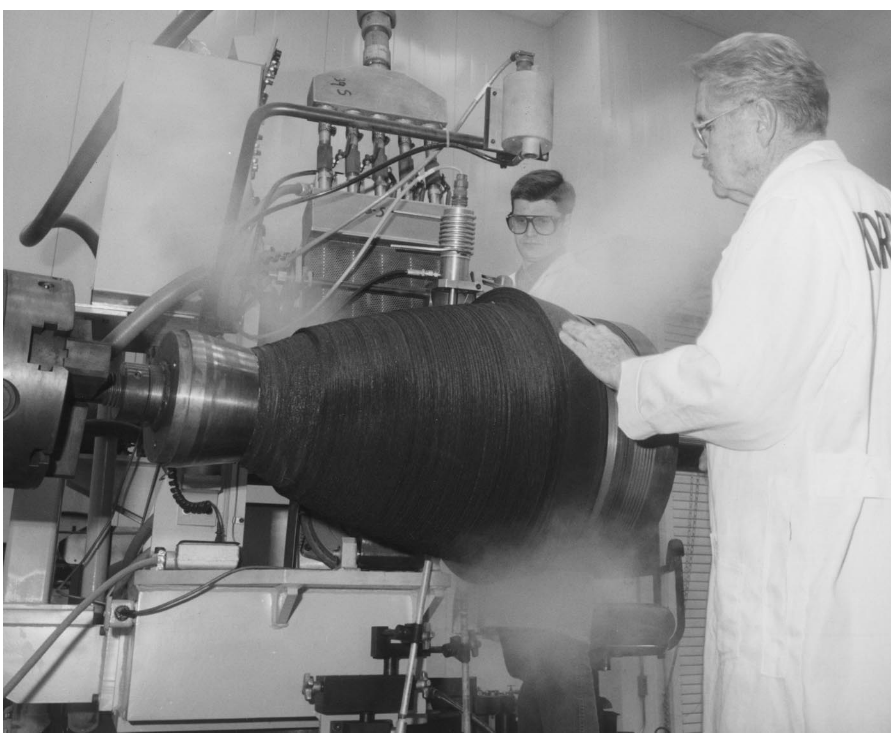

FIGURE 203.—The filament winding machine lays down layers of resin/fiber composite ribbons until the desired thickness and strength is achieved.

The lab’s final capability involves resin transfer molding. “We have very limited capabilities in this at Marshall since this technology is more suited to being used in producing high-quantity precision components in a commercial manufacturing set-up,” Vickers explained.

The laboratory is heavily involved in pushing the strength envelope of candidate composite materials for development of the Reusable Launch Vehicle for the nation’s space program. Still, Vickers said, the lab is available to support less time-consuming projects on a time- and equipment-available basis. As examples of this, the lab is developing an instrumented obstetrical forceps to enable physicians to more safely position fetuses in the womb in instrument-assisted deliveries. Gauges on the instrument will enable the physician to avoid placing too much pressure or stress on the infant. Vickers was one of several materials engineers who recently worked on development of a racing wheelchair design, made of composites, that is now being manufactured commercially.

Research into high-strength, high-durability, low-cost composites at the

Marshall Center is creating a technology data base which should benefit American industries and which is available to them under NASA's technology transfer program. Up to 40 hours of technical assistance can be provided by NASA's Marshall Center to U.S. firms, free of charge. For further information, call 1–800–USA–NASA.

Sponsor: Office of Commercial Development and Technology Transfer

Biographical Sketch: Bob Lessels is the technical writer/editor (physical sciences) for the Technology Transfer Office at the Marshall Center. A graduate of the University of Nebraska, he has been a professional journalist for the past 30 years. He joined NASA in 1986.